

ANALYSYS OF TEMPARATURE & HEAT FLUX OF COATED AND NON-COATED PISTONS BY USING (YSZ) MATERIAL

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ABSTRACT

The greater parts of the buyers of transportation utilize petroleum and diesel as fuel. Because of the expansion in the use of these items, there is need of increment in productivity of power producing machines. The performance of the engine is mostly affected by heat loss to the components of engine like a piston. In this project, the heat absorbed by the piston is reduced using a thermal barrier coating (TBC) technique. The ceramic material yttria Stabilized Zirconia (YSZ) is used for the coating process for a considerable increase in performance of I. C engine. The piston is modeled in Pro-e and thermal analysis is done in ANSYS. Transient thermal analysis is done on both non coated aluminum piston and YSZ coated aluminum piston. In the end, the results of both coated and non-coated pistons are compared to find out the better performing condition of an engine.

KEYWORDS: Yttria Stabilized Zirconia (YSZ) & Thermal Barrier Coating (TBC)

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INTRODUCTION

Nowadays internal combustion (IC) engines are most popular among all kinds of power generating systems. These are mostly used in automobiles for transportation purpose. IC engines are of two types which are Spark ignition engine (SI) and Compression ignition engine (CI). SI works on the principle of Otto cycle, whereas CI engines work on the principle of diesel cycle. In SI engines an electric sparking mechanism is used to ignite the fuel before it reaches to its self-igniting igniting temperature to avoid knocking, in SI engines due to the fuel's low compression ratio it causes abnormal combustion which leads to more vibrations called knocking.

CI engines are the most popular engines among all IC engines because of their efficiency and fuel economy. When compared to SI engines CI engines are more efficient. CI doesn't require any kind of igniting mechanism because of its self-igniting ability. Diesel is having a high compression ratio so it can ignite itself at high pressure and temperatures by avoiding knocking. These engines are made so heavy to damp the vibrations caused by high pressure. CI engines are mostly two types, direct injection system (DI) and indirect injection system (IDI).

In IDI system engine, it contains two different chamber,s one is pre-combustion chamber and main chamber. There are two variations of pre-combustion chambers one is Pre-combustion chamber itself and the other is the air-cell chamber, although there some more variation but these two are mostly used designs. In IDI the fuel is

pre ignited in pre-combustion chamber and then sent to the main combustion chamber. Glow plug and single orifice nozzle are used for injection system. More atomization and high compression ratios are possible in this type of system.

In DI system, it contains only the main combustion chamber and the fuel is directly injected into it by using different types of nozzles having multiple holes to get more atomization requirement because of less swirling of air in the chamber. DI system engines are more thermally efficient when compare IDI system engines due to less wall area.

These engines vastly used a heavy vehicle for very longer transportation there is the need to increase in efficiency for much better performance. Since these engines work on self-ignition caused by high pressure and temperature generated inside the chamber there must be an insulation ,which avoids the escape of temperature, which is otherwise called as low heat rejection (LHR) is required.

Low Heat Rejection (LHR)

The combustion process in IC engines is the chemical reaction between a fuel and air (Oxidant), only about one-third part of the heat generated in this process is used to do work and 3remaining heat is lost to engine parts in the form of conduction and to coolant in the form of convection. CI engines work at high compression ratios so it is required to insulate the chamber from the escape of heat. These results to the minimum rejection of heat to other parts which increases the thermal efficiency of the engines. To attain LHR engine parts is coated with different types of insulating materials that are having required properties like high hardness, low thermal conductivity. This type of coating is called Thermal barrier coating (TBC).

Thermal Barrier Coated Engine

A thermal barrier coated engine will act as an adiabatic engine. In an adiabatic condition, the heat transfer 'Q' will be zero. Although heat cannot be zero. but when compared to the normal engine TBC engine will have very less heat loss. This engine chamber is made up of material which allows the combustion process with minimal heat loss to the surroundings. In this, the thermal efficiency will be increased because of bringing the heat loss to minimum level and converting it into useful work.

Different Materials used for TBC

Ceramics, these are very popular materials among all other materials. Ceramics has a wide range of applications like building materials, refractories, insulators, magnetic materials, dielectrics etc. Materials that are used for the mechanical purpose are stronger in their properties, usually specially prepared for their fine grain structure and density which develops their mechanical properties as per the usage.

Two different materials are used to coat on the piston one is for bonding purposes and the other is the ceramic material itself.

Different Methods of Coating

- Plasma spray coating
- Ion coating
- Chemical vapour decomposition

- Physical vapour decomposition5. Splash coating.

Plasma Spray Coating

Plasma spray is a thermal spray coating process used to create a fantastic coating by a mix of high temperature, high vitality heat source, a moderately dormant spraying medium, generally argon, and high particle speeds. Plasma is the term used to portray gas, which has been raised to such a high temperature, to the point that it ionizes.

Advantages

The considerable preferred standpoint of the plasma spray coating is its capability to spray a lot many varieties of materials, all the way from metals to refractory ceramics, on both large and small integrants providing

- Resistance from corrosion
- Resistant to wear
- Abrasive
- Resistant to oxidation and Heat
- Management of various temperatures
- Electrical resistivity and conductivity

Applications

Because of its adaptability and fantastic attributes, the plasma spray coating process is chosen by numerous technologists as a procedure which offers the vastest decision of coating materials

- High temperature security
- Gas turbine combustion equipment
- Resistant to wear
- Printing rolls for laser engraving

Modelling

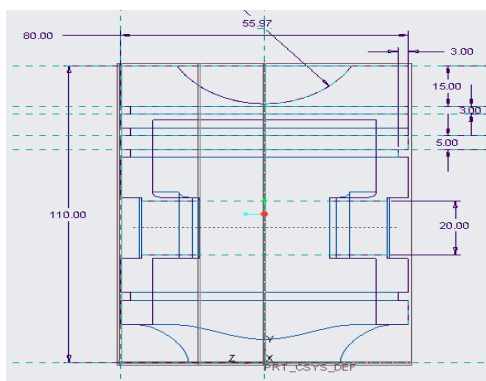


Figure 1: Piston Dimensions.

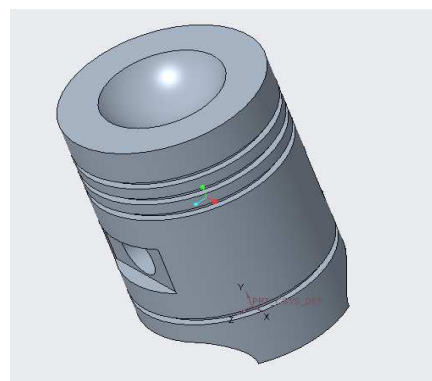


Figure 2: Piston Model in Pro-E

Analysis

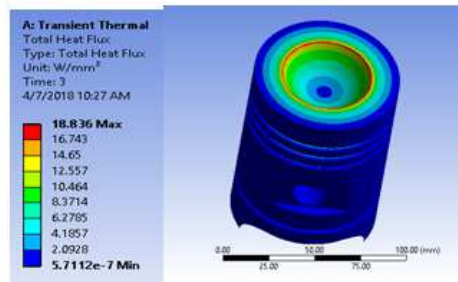


Figure 3: Heat Flux Aluminum

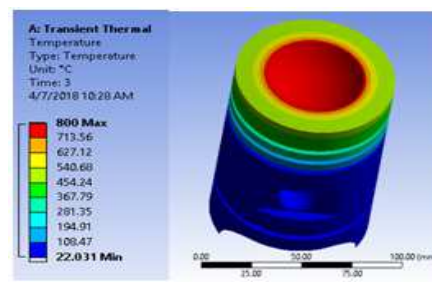


Figure 4: Temperature Aluminum

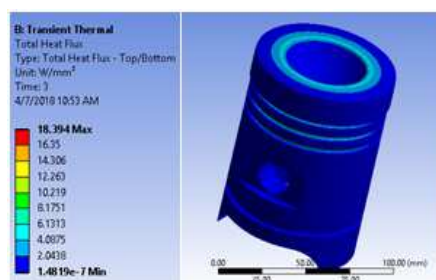


Figure 5: Heat Flux of Coated Piston

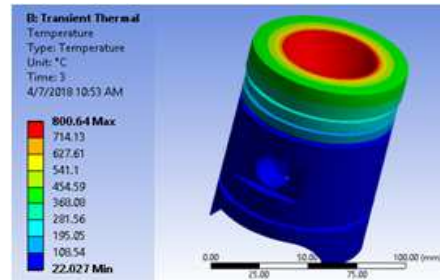


Figure 6: Temperature of Coated Piston

RESULTS AND DISCUSSIONS

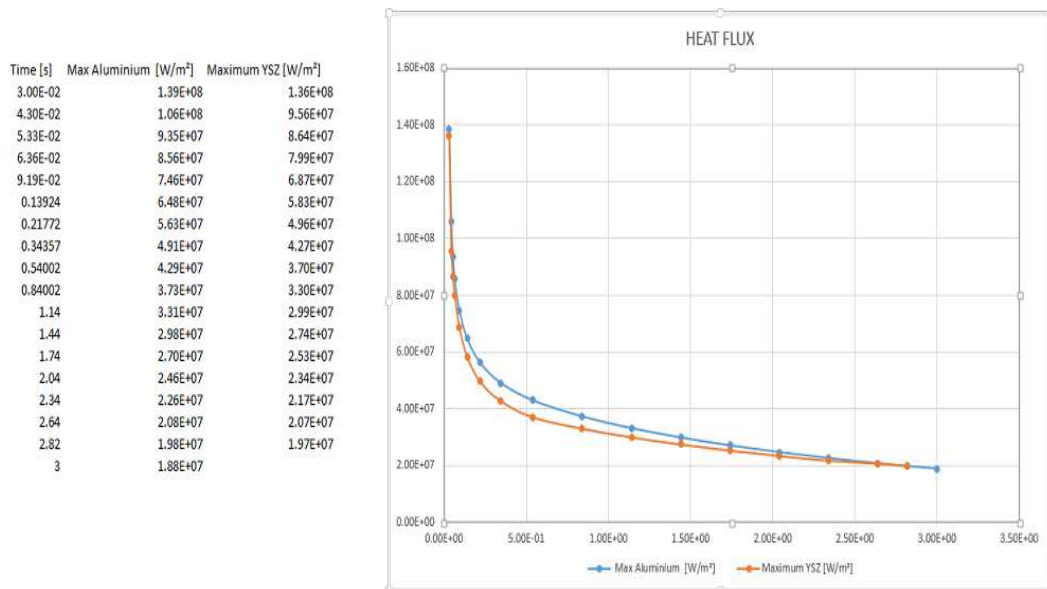


Figure 7: Max and Min Values of Heat Flux Aluminum and YSZ

Time [s]	Maximum_aluminium [°C]	Maximum_YSZ [°C]
3.00E-02	800	800
6.36E-02	800	803.87
7.59E-02	800	803.35
9.19E-02	800	802.94
0.13924	800	802.27
0.21772	800	801.73
0.34357	800	801.35
0.54002	800	801.1
0.84002	800	800.91
1.14	800	800.8
1.44	800	800.72
1.74	800	800.66
2.04	800	800.6
2.34	800	800.56
2.64	800	800.52
2.82	800	800.49
3	800	800.47

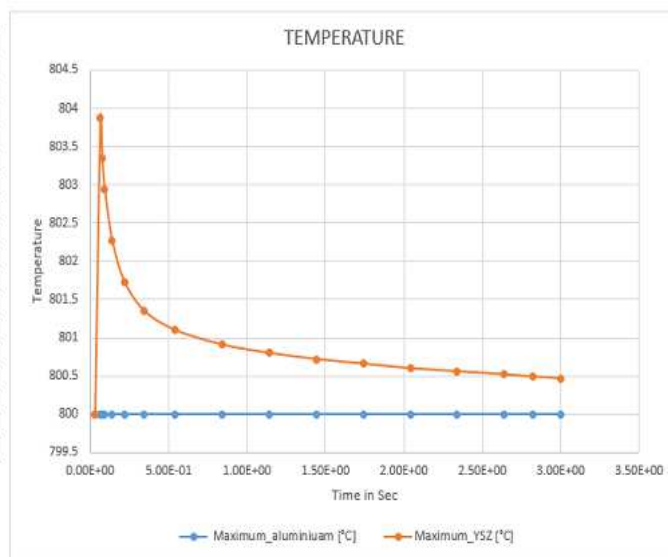


Figure 8: Max and Min of Temperature Aluminum and YSZ

- From the obtained results the maximum temperature recorded for the coated piston is more than the temperature recorded in the non-coated piston
- The heat flux for the coated piston is lesser than the heat flux of the non-coated piston which provides low heat rejection to the piston. And these results increase in the performance of the engine.

CONCLUSIONS

By performing transient heat analysis on both YSZ coated and non-coated pistons the temperature and heat flux with the coated piston shows better results when compared to the non-coated piston. From the graphs, heat flux of the coated piston is decreased compared to non-coated piston and temperature of the coated piston is increased comparatively, which results from better combustion.

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